

## CLAIMS

### What is claimed is:

1. A method for correcting a defective ball grid array on an electronic component workpiece, the method comprising:  
5 identifying at least one defective solder ball associated with a corresponding attachment site of a ball grid array on a workpiece; and  
extracting the at least one defective solder ball to vacate the corresponding attachment site and replacing the at least one defective solder ball with a non-defective solder ball on the vacated attachment site while maintaining other solder balls of the ball  
10 grid array in undisturbed arrayed attachment to the workpiece.
2. The method of claim 1, wherein the at least one defective solder ball comprises a plurality of defective solder balls, and further comprising extracting and replacing each defective solder ball of the plurality while maintaining other solder balls  
15 of the ball grid array in undisturbed arrayed attachment to the workpiece.
3. The method of claim 1, wherein the at least one defective solder ball is extracted by individually heating the at least one defective solder ball to effectuate release thereof from the corresponding attachment site and lifting the heated at least one  
20 defective solder ball from the corresponding attachment site using a vacuum.
4. The method of claim 1, wherein the at least one defective solder ball is extracted by individually heating the at least one defective solder ball to a molten state and removing molten solder from the corresponding attachment site by capillary action.  
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5. The method of claim 4, further comprising assisting the capillary action by application of a vacuum.

6. The method of claim 1, further comprising lifting the non-defective solder ball, positioning the non-defective solder ball on the vacated attachment site and heating the non-defective solder ball at least to a temperature to cause the non-defective solder ball to bond to the attachment site.

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7. The method of claim 6, further comprising lifting the non-defective solder ball using a vacuum provided through a capillary tube, and heating the non-defective solder ball through the capillary tube.

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8. The method of claim 6, comprising applying flux to the non-defective solder ball prior to the positioning thereof on the vacated attachment site.

9. The method of claim 6, further comprising applying flux to the vacated attachment site prior to positioning of the non-defective solder ball thereon.

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10. A method for removing a solder ball from an attachment site of a ball grid array on an electronic component workpiece, the method comprising:  
vertically aligning a capillary tube with a solder ball of a ball grid array;  
lowering the capillary tube to contact the solder ball from above;  
heating the solder ball with heat conducted from a heat source through the capillary tube  
to facilitate removal of the solder ball from an attachment site to the workpiece;  
and  
retracting the capillary tube to extract the solder ball from the attachment site.

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11. The method of claim 10, further comprising heating the solder ball sufficiently to reduce the solder thereof to a molten state, and drawing the solder in a molten state into the capillary tube.

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12. The method of claim 11, further comprising drawing a vacuum through the capillary tube to facilitate drawing the solder in a molten state thereinto.

13. The method of claim 10, further comprising heating the solder ball sufficiently to release a bond thereof to the attachment site.

14. The method of claim 13, further comprising drawing a vacuum through the capillary tube to retain the solder ball at an end of the capillary tube during the retraction thereof.

15. The method of claim 10, wherein removal of the solder ball comprises removal of a defective solder ball.

16. A method for extracting and removing at least one defective solder ball from an attachment site in a ball grid array of an electronic component workpiece, comprising the steps of:  
placing the electronic component workpiece on a support;  
viewing the ball grid array under magnification to identify and locate at least one defective solder ball in the ball grid array;  
providing a ball pickup head comprising a capillary tube having a heater operably connected thereto;  
positioning the capillary tube over the at least one defective solder ball and extending the capillary tube to contact the at least one defective solder ball;  
applying heat from the heater through the capillary tube to the at least one defective solder ball to at least weaken a bond thereof to an attachment site on the electronic component workpiece; and  
removing the at least one defective solder ball from the attachment site with the capillary tube.

17. The method of claim 16, further comprising cooling the at least one defective solder ball, moving the capillary tube and cooled solder ball to a location remote from the electronic component workpiece and releasing the at least one defective solder ball from the capillary tube.

18. The method of claim 16, further comprising applying sufficient heat to the at least one defective solder ball to reduce it to a molten state, and removing the molten solder material with the capillary tube using at least capillary action.

5 19. The method of claim 18, further comprising applying a vacuum to the molten solder material through the capillary tube.

10 20. The method of claim 16, further comprising applying sufficient heat to the at least one defective solder ball to cause it to release from the attachment site without completely melting and applying a vacuum to the at least one defective solder ball to retain the at least one defective solder ball at an end of the capillary tube prior to the removal of the at least one defective solder ball from the attachment site.

15 21. The method of claim 16, further comprising:  
providing a source of good solder balls;  
retrieving a good solder ball with the capillary tube by applying a vacuum through the capillary tube;  
applying flux to one of the solder ball and the vacated attachment site;  
aligning the good solder ball with the vacated attachment site using the capillary tube;  
20 placing the good solder ball in contact with the vacated attachment site;  
heating the good solder ball through the capillary tube at least sufficiently to cause the good solder ball to bond to the vacated attachment site; and  
releasing the good solder ball from the capillary tube.

25 22. The method of claim 16, further comprising performing at least some of the steps of the method under control of a programmed microprocessor.

30 23. The method of claim 22, wherein the viewing the enlargement of the ball grid array is performed using a machine vision system.

24. The method of claim 23, further including using the machine vision system  
in combination with a programmed microprocessor and data stored in memory to  
compare the viewed ball grid array with a model ball grid array and to locate the at least  
5 one defective solder ball in the viewed ball grid array.

25. An apparatus for at least extracting an individual solder ball mounted on  
an attachment site on an electronic component workpiece, the apparatus comprising:  
a support configured to receive an electronic workpiece thereon;  
10 a solder ball contact head, comprising:  
a capillary tube including a distal end having an inside diameter less than a  
diameter of an individual solder ball of a plurality of solder balls mounted  
in an array over a surface of electronic component workpiece;  
a heating device operably coupled to the capillary tube;  
15 structure for aligning the capillary tube with the mounted solder ball in substantially  
transverse orientation to the electronic component workpiece surface; and  
an assembly for controllably extending and retracting the capillary tube toward and away  
from the surface of the electronic component workpiece.

26. The apparatus of claim 25, further including a vacuum source selectively  
operably coupled to the capillary tube for drawing a vacuum therethrough.

27. The apparatus of claim 25, further including structure for effecting  
alignment of the support in X- and Y-directions.

28. The apparatus of claim 25, further including a viewing apparatus  
configured for magnification and orientable over the surface of the electronic workpiece  
component when the electronic workpiece component is received on the support.

29. The apparatus of claim 28, wherein the viewing apparatus includes at least one of at least one eyepiece for viewing and a camera for generating an electronic image.

30. The apparatus of claim 28, further including a light source orientable for illuminating the surface of the electronic component workpiece.

31. The apparatus of claim 30, wherein the contact head is configured for transmission of at least a portion of the illumination from the light source therethrough.

32. The apparatus of claim 31, wherein the contact head is configured with a window in alignment with a bore extending through the capillary tube.

33. The apparatus of claim 31, wherein the contact head is configured with at least one optical fiber positioned to received light from the light source and extending to a location to transmit the received light onto the surface of the electronic component workpiece.

34. The apparatus of claim 16, further comprising a source of non-defective solder balls in proximity to the contact head.

35. The apparatus of claim 25, wherein said structure for aligning comprises a machine vision apparatus including a camera, magnifying lens, at least one programmed microprocessor and memory having data stored therein representative of the surface of the electronic component workpiece and topography thereof.

36. The apparatus of claim 35, wherein the memory further includes stored data usable by the at least one microprocessor for identifying defective solder balls within the array.

37. The apparatus of claim 36, wherein the at least one microprocessor is programmed to control at least some movements of the contact head and operation of the heating device.

5 38. The apparatus of claim 25, wherein the contact head is resiliently biased to yield responsive to contact of the capillary tube with a solder ball of the array.

39. The apparatus of claim 25, further including a retraction device for selectively retracting the capillary tube toward the contact head.